BULLETIN

Pennsylvania Department of Agriculture

HARRISBURG

Vol. 9 September 1 - 15, 1926 No. 16

General Bulletin No. 433

Grape Insects and Diseases

By J. R. Eyer and W. A. McCubbin

Pennsylvania Produced 25,110 Tons of Grapes valued at $854,000 in 1926

F. P. WILLITS, *Secretary of Agriculture*
C. H. HADLEY, *Director, Bureau of Plant Industry*

Published semi-monthly by direction of the Secretary. Entered as second class matter, March 22, 1918, at the Post Office at Harrisburg, Pa., under the Act of June 6, 1900. Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on June 29, 1913.

A WAR ON GRAPE PESTS!

Grape Insects and Diseases

By J. R. Eyer Ph.D. and W. A. McCubbin M. A.[1]

Bureau of Plant Industry

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This bulletin is published to furnish the grape growers of Pennsylvania with descriptions of the more injurious grape pests and the best known methods for their control. A brief description is given of each pest and the nature of its injury, and especial emphasis is placed on recent developments in control measures. Most noteworthy of these are the perfecting of improved types of spray booms which have largely supplanted the spray rods formerly used, the introduction of compounds known as "stickers and spreaders" which have added materially to the adhesive and covering properties of the standard spray materials, and the discovery of the ovicidal or egg-killing value of nicotine sulfate in connection with the control of the grape leaf hopper. In addition, studies of the seasonal histories and activities of grape pests in Pennsylvania have furnished the basis for the formulation of a spray schedule which is well adapted to meet yearly variations in the occurrence of these insects and diseases.

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1 It is impossible to acknowledge specifically all of the sources drawn upon in the preparation of this bulletin. The work has been done in part in cooperation with the Bureau of Entomology of the U. S. Department of Agriculture, and the Department of Agriculture Extension of the Pennsylvania State College through the Erie County Farm Bureau. The Fredonia Laboratory of the New York Agricultural Experiment Station has given much in the way of counsel and advice. The authors have made use of notes made by other workers with or at one time connected with the Bureau of Plant Industry and here acknowledge their indebtedness. Observations for much of the data used were made at the field office of the Bureau of Plant Industry, North East, Erie County. This office has been working on grape pests since 1918 when the work started by the U. S. Department of Agriculture was taken over by the Bureau.

GRAPE LEAFHOPPER

(*Erythroneaura comes* (Say)

The adult grape leafhopper is a small, yellowish, winged insect about one-eighth inch long, irregularly marked with reddish or reddish-brown stripes and patches. The nymph, or immature insect, resembles the adult in general shape, but possesses only rudimentary wings and is lighter in color. Both nymphs and adults are quite active, quick to go about over the leaves, and are usually found on the lower surface.

A Serious Grape Pest

During recent years this insect has become one of the most serious pests of grapes in Pennsylvania. Periodic outbreaks have occurred in 1901, 1902, 1911, 1922, and 1923, in Erie County. Both adults and nymphs feed by inserting their beak-like mouth parts into the leaves and sucking out the sap. Portions of the leaf on which the hoppers have fed die, and where feeding is extensive, the leaf withers and falls. See Fig. 1. This injury decreases the quanity of fruit

Fig. I. Grape Leaves Damaged by the Grape Leaf Hopper

and prevents its proper ripening. It also decreases the quanity and quality of the fruiting wood.

How the Insect Lives

The adults overwinter in herbage, plant rubbish, and waste places in or near the vineyards. They are active during warm days in the winter and spring, and feed on a variety of weeds and grasses. In late April or early May most of them are feeding on strawberry, later on raspberry, and in May or early June they migrate to grape. Eggs are laid in the foliage and the young nymphs soon hatch. Some of these nymphs complete their growth in about a month, change to adults and lay eggs for a second generation. In Pennsylvania this second generation is usually small and may be largely prevented by directing proper control measures against the first generation.

Spray is Effective Control

In the past the grape leafhopper has been controlled with nicotine sulfate ("Black Leaf 40") in the form of a spray applied when the maximum number of nymphs is present on the foliage and before many of them have transformed to adults. The chief difficulty in following this practice lies in ascertaining the exact time when the majority of leafhoppers have hatched from the eggs. Observations in Pennsylvania have shown that the interval elapsing between the hatching of most of the eggs, and the appearance of the adults of the second generation, is extremely small, usually four to seven days.

Following the recommendations of Mr. W. A. Ross of the Vineland Laboratory, Ontario, Canada, tests were made to ascertain the value of nicotine sulfate as a spray for killing the eggs of this insect. Experiments conducted in 1923, 1924 and 1925 have shown conclusively that nicotine sulfate ("Black Leaf 40"), 1 to 800 (1 pint per 100 gal.), combined with hydrated lime 10 pounds to 100 gallons, or with Bordeaux mixture 4-4-50, will kill practically all eggs in the foliage at the time of spraying. The spray must be applied under pressure of 200 to 250 pounds, using not less than 150 gallons of material per acre. Nozzles of the disc type, having large apertures and delivering a coarse spray, are most satisfactory. (See page 21).

Experiments with Dusting

Nicotine dusts containing one, two, three and four per cent nicotine have been tested as controls for grape leafhopper, but none have consistently given satisfactory control. The three per cent and four per cent dusts applied at the rate of 30 pounds per acre proved more satisfactory than those of lower strengths. At temperatures ranging

from 70 to 80 degrees Fahr., and at a relative humidity of 65 per cent, the three per cent dust killed an average of 58 per cent of the leafhopper nymphs, and the four per cent, 76 per cent. At a temperature of 60 degrees Fahr. killing was extremely uncertain. The adults were apparently killed by the dust, but many recovered a short time after dusting.

Calcium cyanide dust was found very effective in killing both the nymphs and adults. The so-called "A" dust, consisting of pure calcium cyanide, killed from 85 to 90 per cent of the nymphs and 70 to 75 per cent of the adults at a temperature of 70 degrees Fahr. This material burns grape foliage and is unsafe to use during periods of high humidity or when the foliage is moistened by dew or rain. It shows promise however as a material for killing the leafhoppers as they come from hibernation in the spring. Waste land and raspberry plantings adjoining vineyards have been dusted prior to the migration of the adults to grape, and it was found that this so reduced the infestation of the vineyard that further spraying was unnecessary. Such a practice is advisable only when the leafhoppers are found concentrated in large numbers on vegetation surrounding the vineyard.

Cultural Practices Aid in Control

Burning over waste land adjoining vineyards in late fall or early spring to destroy hibernating leafhoppers has been found practical in cases where the burning can be effected without endangering surrounding property or vegetation. Clean farming will destroy the hibernating places of the adults, and reduce infestation in the early spring.

GRAPE ROOT-WORM
(*Fidia viticida* Walsh)

The grape root-worm is a small, white grub about three-eighths inch long, broad in proportion to its length, with a yellowish brown head and thoracic shield. The beetle is about one-fourth inch long, reddish brown in color, and covered with short gray hairs which give it a grayish brown appearance.

Injury often Concealed

This insect ranks with the grape leafhopper as one of the most in-
foliage making chain-like incisions, and occasionally reduce the
foliage making chain-like incisions, and occasionally reduce the leaves to shreds. The grubs consume the smaller roots and rootlets and eat furrows into the larger roots and crown. Such injury decreases the vigor and growth of the grape vines, decreases their fruit

production, predisposes them to disease and winter injury, and ultimately causes their death. Because of the concealed feeding habits of the grubs and the indirect nature of the injury, its severity is often under-estimated.

The adults emerge from pupae in the soil late in June or early in July. They feed on the grape foliage for about two weeks. Eggs are laid beneath the loose bark of the old canes and the stock. The grubs hatch, drop to the ground, make their way to the roots and commence feeding. The partially grown grub spends the winter in the soil, resumes feeding in the spring and in June forms a cell in which it changes into the beetle.

Successful Control Methods

Spraying with an arsenical to poison the beetles and cultivation of the vineyard at the time the insect is in the pupal stage are the most satisfactory methods of control.

Spraying with Bordeaux mixture 4-4-50 to which arsenate of lead is added at the rate of three pounds per 100 gallons has been found most satisfactory for controlling the adults. This spray must be applied within a week after the first adults appear, and if the beetles are extremely numerous should be followed by a second spray 10 days later. When the beetles appear with the setting of the grape berries the first spray will be effective against the first brood of the berry moth, and nicotine added to the second spray will ordinarily control the grape leafhopper as most of the eggs are laid in the foliage by this time.

Cultural Practices. (1) Leave a low ridge under the veins at the time of the last cultivation in the summer. (2) Remove this ridge with a horse or hand hoe in June of the following spring after the grubs have become inactive. (3) Cultivate the soil to a depth of three inches around and under the vines.

GRAPE BERRY MOTH
(Polychrosis viteana Clem.)

The adult of the grape berry moth is about one-fifth of an inch long and purplish brown in color. The larva or "worm" is about three-eighths inch long when full grown, varies from green to purplish brown in color, and has a light brown head and black thoracic shield.

In the past the grape berry moth has ranked with the leafhopper and root worm as a serious pest of grapes in Pennsylvania. In recent years infestation has been less severe owing to more careful spraying and cleaner farm practices of the growers. The larvae feed on the blossom clusters early in the spring, webbing them to-

gether and destroying them; they tunnel in the stem and eat out a portion of the newly formed berries; and later feed on the pulp and immature seeds of the ripening berries. See Fig. 2. This injury seriously affects both the quality and quantity of the fruit.

Fig. 2. Grapes Damaged by the Grape Berry Moth

Life History

The grape berry moth usually passes the winter as a pupa in a cocoon spun in decayed and damp leaves on the ground. The moths emerge about the middle of June, eggs are laid on the stems of the blossom clusters, and the young larvae feed as above described. They become full grown in about a month, spin a cocoon beneath a flap cut in the leaf (see Fig. 3), and the moths emerge about two weeks later. Two generations and a partial third occur in Pennsylvania, but these overlap to such an extent that larvae of all sizes are found in the ripening grapes. Occasionally full grown larvae are found webbing the blossom buds in the early spring be-

Fig. 3. Cocoons of the Grape Berry Moth

fore the normal emergence period of the moths. These larvae, which have undoubtedly hibernated over winter, add further irregularity to the generations.

Spraying Controls this Moth

Arsenate of lead 3 pounds per 100 gallons combined with Bordeaux mixture 4-4-50 applied shortly after the fruit sets and again just before the berries touch in the cluster, has effectively controlled the berry moth in Pennsylvania. Resin fish oil soap at the rate of 3 pounds per 100 gallons, or "Sunoco" spray oil ½ gallon per 100 added to the above mixture greatly assists in sticking and spreading the materials on the grape berries. With light or moderate infestations the spray may be applied with either of the booms described in the paragraphs on boom construction. Where infestation is extremely heavy better results can be obtained by using "trailers" or spray rods equipped with angle nozzles, taking care to thoroughly cover the clusters with spray material.

Clean Culture Important

Practice clean culture in late summer; sow a cover crop and allow all fallen leaves to remain uncovered until the following spring. This increases the mortality of the overwintering pupae by exposing the fallen leaves in which the cocoons are spun. Cut back woodlands and weedy fence rows adjoining vineyards to prevent the accumulation of trash and drifting of snow which protects the cocoons.

ROSE CHAFER

(*Macrodactylus subspinosus* (Fab.))

The rose chafer or "rose bug" is a grayish brown beetle about one-half inch in length with long reddish brown legs. The grub resembles the white grub or June beetle larva, but is smaller.

This insect is only injurious to grape in the beetle stage and feeds on the blossom clusters, newly set berries, and leaves. This injury produces thin clusters, thus reducing the quantity of fruit. Because the rose chafer only infests vineyards adjoining sandy wastelands where it breeds, and because it feeds on the grape for only a short time at the blossoming period, its injury is local in character.

The rose chafer passes the winter as a grub in the soil. It pupates in May and the beetles emerge early in June. They feed on the blossoms and young fruit of a variety of shrubs and trees beside grapes; and after mating deposit their eggs in waste grasslands near the vineyards and orchards. The grubs feed on the roots of various grasses.

Poison Sprays Reduce Loss

Experiments in Pennsylvania have demonstrated that arsenate of lead 4 pounds, molasses 2 gallons, and water 100 gallons will poison the beetles and greatly reduce infestations in the vineyards. A spray which is in current use for the control of the Japanese beetle, consisting of 6 pounds of acid lead arsenate, 4 pounds of wheat flour and 100 gallons of water, has also given excellent control. Sodium fluosilicate (95 per cent) mixed with hydrated lime in proportions 1 to 6 and 1 to 8, and used as a dust, killed the beetles but frequently burned the foliage. It may be regarded as a promising material, but is still in the experimental stage. For satisfactory control any of these materials must be applied as soon as the first beetles appear and before any extensive feeding has taken place. If the beetles continue to appear in large numbers or heavy rains occur shortly after spraying, a second spray is advisable.

Cultural Practices. Utilize all sandy wasteland by planting it to crops which require cultivation in May and June. If the land is inarable plant it to clover or alfalfa.

JAPANESE BEETLE

(*Popillia japonica* Newm.)

The Japanese beetle is a beautiful insect about the size of a potato beetle, but more elongate. The head and thorax are shining bronze green and the elytra or wing covers are brownish, tinged with green at the edges. On the sides and at the tip of the abdomen, usually not concealed by the wing covers, are conspicuous white spots, which distinguish this species from all others of the same size and habits occurring in Pennsylvania.

The Japanese beetle is now (1926) found in the southeastern quarter of Pennsylvania. The insect does its damage to grapes by feeding on the foliage and developing berries. The leaves are skeletonized, and the vine has a burned appearance when viewed from a distance. (See Fig. 4)

Fig. 4. Grape Leaves Damaged by Japanese Beetles

Life History

The life history of the Japanese beetle as known at present is as follows:—The winter is passed in the soil in the grub stage. The grubs are found to a depth of from one-half to twelve inches below the surface. They come closer to the surface in late March or early April, and resume feeding. The older grubs complete their growth early in June, when they prepare an earthen cell in which they transform from the pupal stage and emerge as the adult beetle about two weeks later.

The first beetles to emerge will appear about the last week in June, and beetles continue to appear for about six weeks. The length of life of the individual varies considerably, averaging from one to ten weeks. After feeding for several days the female beetle lays her eggs in the ground. These eggs later hatch into small grubs which begin feeding on decaying vegetable matter and living plant roots.

Control by Spraying

The usual grape spray schedule recommends a 4-4-50 Bordeaux mixture with a pound and one-half of powdered arsenate of lead. For the control of the Japanese beetle the same strength of Bordeaux should be used with the addition of 3 pounds of powdered arsenate of lead to each 50 gallons. The application should be completed by June 25th, or at about the time the first beetles begin to emerge. This cover must be very thorough. It is not practical to make spray applications on grapes after the second week of July, since later sprays may leave spray residue upon the berries at picking time. The beetles do some damage later on, but it will be confined to such foliage as has grown since the time of making the spray application.

Bulletins 390 and 406 of Pennsylvania Department of Agriculture give complete information on life history and control of the Japanese beetle.

GRAPE FLEA BEETLE

(*Haltica chalybea* ILL.)

The flea beetle is a small, shining, steel-blue insect about one-fifth of an inch long which jumps when disturbed. The full grown larva or grub is about one-third inch long, dark yellowish brown in color and marked with regular transverse rows of black spots.

The chief injury in Pennsylvania is caused by the adults feeding on the swelling buds in early spring. This feeding often results in the killing of most of the primary buds and the consequent destruction of a large per cent of the blossoms and fruit. The larvae eat irregular holes in the leaves and usually work from the upper surface.

Life History and Control

The adults hibernate during the winter in rubbish or under the bark of trees, and appear in the vineyards on warm days in early spring. Eggs are laid in crevices under the bark of the canes and the hatching larvae feed on the foliage. The mature larvae pupate in the soil in late June and July, and the beetles which emerge feed on wild grapevines for the remainder of the season. Only one generation occurs each year.

The Bordeaux-arsenical sprays already recommended for other leaf eating insects kill the larvae of the flea beetle and ordinarily keep this insect in check. If, however, adults appear in abundance on the swelling buds a spray of 6 pounds of powdered lead arsenate to 100 gallons of water will prevent serious injury.

CLIMBING CUTWORMS

(*Hadena arctica* Boisd., *Porosagrotis vestusta* Walk., et al.)

Cutworms, which are the larvae of night flying (Noctuid) moths, occasionally feed on the grape buds in early spring. These caterpillars range from one to nearly two inches in length and are dull gray or brown with obscure dark colored markings. During the day they hide in the soil or beneath debris and vegetation near the vineyard and at night climb up the vines to feed. They are most abundant in vineyards planted on light sandy soil and where grass and weeds are growing.

Poison Bran Mash Recommended

The most effective control for cutworms is a poison bran mash composed of bran 20 pounds, white arsenic or Paris green 1 pound, and molasses one-half gallon. Mix the bran and Paris green dry and then add the molasses and sufficient water to form a thick paste. Scatter a handful of the bait around the base of each vine at nightfall.

Thorough cultivation of the vineyard and adjoining land will destroy the natural breeding places of these pests

BLACK ROT

(*Guignardia bidwellii* (Ellis) V. & R.)

Black rot is in general the most destructive disease of the grape, since it directly attacks and destroys the berries and renders the bunches which survive very unsightly. It is a widespread disease but varies in severity according to climate. In the warmer southern portions of the state it is more damaging than in the cool sections near Lake Erie.

Attacks on the fruit are usually accompanied by a spotting of the leaves and these spots may be so numerous that the leaves are weakened and fall early. It is needless to say that this weakening of foliage has a direct effect on the size and ripening of the berries.

How to Recognize this Disease

The fungus causing black rot lives over winter in the rotted fruit and in spring produces a crop of spores which infect the new leaves and fruit. The spots on leaves are usually small, more or less rounded in outline, and have a light brown or greyish center with brown margin. (See Fig. 5) Under a hand lens, small black dots may be seen in the dead tissue—the spore-producing organs of the fungus.

Fig. 5. Black Rot on Leaves

On the fruit the fungus causes a rot which results in a shrivelling of the berries into a dark brown mummy, usually closely beset with tiny pimples which are again the spore producing structures.

The extent of the rot on the fruit may vary from the loss of one or two berries in a cluster to the total destruction of the whole cluster. (See Fig. 6) From the spore bearing organs on both leaves

and fruit the spores are spread all through the season, so that if conditions are moist enough for the spores to germinate and infect other leaves and fruit there is a constant increase in the amount of the disease through the summer.

Fig. 6. Black Rot on Fruit

Clean Culture and Spraying Required

From the above outline of the life history of the black rot fungus it will be seen that control methods should be directed along two lines: (1) to prevent or reduce the amount of spring infection from overwintered mummies, and (2) to protect the leaves and fruit during the summer from this infection and from spread of the fungus.

From the first point of view, clean and thorough culture beginning with early plowing in spring is recommended, not only to bury the mummied fruits to a depth that will render them harmless, but also

to keep down weeds which create a moist atmosphere near the soil and thus encourage spore production from mummies at or near the surface. This cultivation is of course otherwise valuable as a means of promoting thrifty vine and fruit growth and conserving moisture.

Protection of the fruit and foliage during the summer is obtained by spraying with Bordeaux mixture, 4-4-50, four or five times: (1) when the new shoots are from 10 to 12 inches long; (2) after the blossoms fall; (3) about two weeks later; (4) about two weeks later. In favorable seasons or if rot is severe, an extra spraying may be desirable, in which case the fifth application may be made in two weeks depending on the weather.

In successful control of black rot spraying should be done from both sides of the row; every portion of the foliage and fruit should be covered; a fine mist under high pressure is more effective than a coarse weak stream; and spraying is more effective before rains than after. On account of the glossy nature of some grape foliage, the use of a sticker is of advantage. Resin fish-oil soap, or "Sunoco" spray oil is recommended (See page 9).

Where black rot has been prevalent in a vineyard one may not get perfect control from the first season's spraying but if the recommendations given are followed, excellent results ought to be obtained in the second year and afterwards.

That black rot may be brought under perfect control even when very severe has been amply demonstrated in the case of a vineyard near Mechanicsburg in Cumberland County. For several years previous to 1922 this vineyard produced practically no salable grapes; the clusters were either entirely destroyed by black rot or had so many berries rotted that they were worthless for market purposes. In the year mentioned the Department used this vineyard for investigating and testing stickers and a general spraying program was put into effect, which gave at least 70 per cent of good salable bunches the same year; and with a continuation of this treatment the next year the loss from rot became negligible. The owner has since continued to spray according to the schedule given, and has had entire freedom from rot. This result gives assurance that even in the warmer southern portions of the state black rot can be controlled in a most satisfactory manner.

POWDERY MILDEW

(*Uncinula necator* (Schw.) Burr)

This disease, while widespread, is not so destructive as the black rot; it is more damaging to varieties of European origin than those coming from native American stock.

This mildew, as the name implies, appears as a powdery or dusty coating on the foliage, shoots, and fruit pedicels. In reality it forms a mat or superficial network of very fine threads on the surface of the grape, feeding by means of suckers or haustoria inserted into the tissues. The dusty appearance comes from immense numbers of upright filaments which break up into numerous colorless spores. The mildew is most conspicuous on the foliage where it forms indefinite patches, usually causing a yellow or sickly area in the leaf beneath. When the leaves are old this discoloration is not so prominent.

How Mildew Causes Damage

The fungus robs the leaf of food materials and weakens it so that it may brown and dry up readily in hot weather. This reduction of leaf activity has a damaging effect on the size, quality, and maturing of the fruit. Toward the end of summer small brown bodies appear on the leaf surface; these are readily visible to the eye, and as they mature they turn dark brown in color. It is these bodies (*peritheeia*) which are said to carry the fungus over winter.

The mildew affects the young shoots at times, but its worst effect aside from the leaf injury mentioned is in attack on the fruit pedicels and stalks. The mildew may be inconspicuous over the rest of the vine and yet be very plentiful in the clusters on the fruit stems. Here it may cause a great deal of shelling, or if the berries do not fall they are shut off from their normal food supply, thus remaining small and immature.

Bordeaux Generally Used for Powdery Mildew

Sulfur dust is the best remedy yet known for powdery mildew when it can be used with safety. It forms a gas at temperatures above 75 degrees Fahr. at which temperatures the mildew is most active; and as the essential parts of the mildew are entirely superficial, this gas readily kills the fungus. Dusting sulfur is best to use, and from one to five applications may be needed in a season, depending on the amount of mildew, the variety, the surrounding conditions, and the weather.

Unfortunately, while sulfur dust appears to be safe to use on varieties of European origin, its use on the varieties derived from American stock is attended by danger of burning. Where this danger is a factor it is better to rely on Bordeaux mixture, which is not perhaps so effective against mildew, but which is safe and may be helpful against other diseases.

In addition to spraying or dusting, other vineyard practices have a relation to mildew. The fungus is distinctly fond of moist condi-

tions and much may be done to keep it in check by keeping vines off the ground, wide spacing, running rows north and south to facilitate quick drying, removing trees and shrubbery which shade the vines, and keeping the vineyard free from weeds which create a layer of moist air near the ground.

DOWNY MILDEW

(Plasmopara viticola (B. & C.) Berl. and deT.)

Downy mildew is not nearly so prevalent in Pennsylvania as the powdery mildew, though the disease is capable of great destruction and in some cases it becomes quite severe.

Symptoms of Downy Mildew

This mildew is not so diffuse and indefinite as the powdery mildew, but tends to form in spots or leaf areas of various sizes (See fig. 7). The tissue of the leaf in this area may be killed outright; or it may merely develop a sickly yellow color; or there may be little apparent

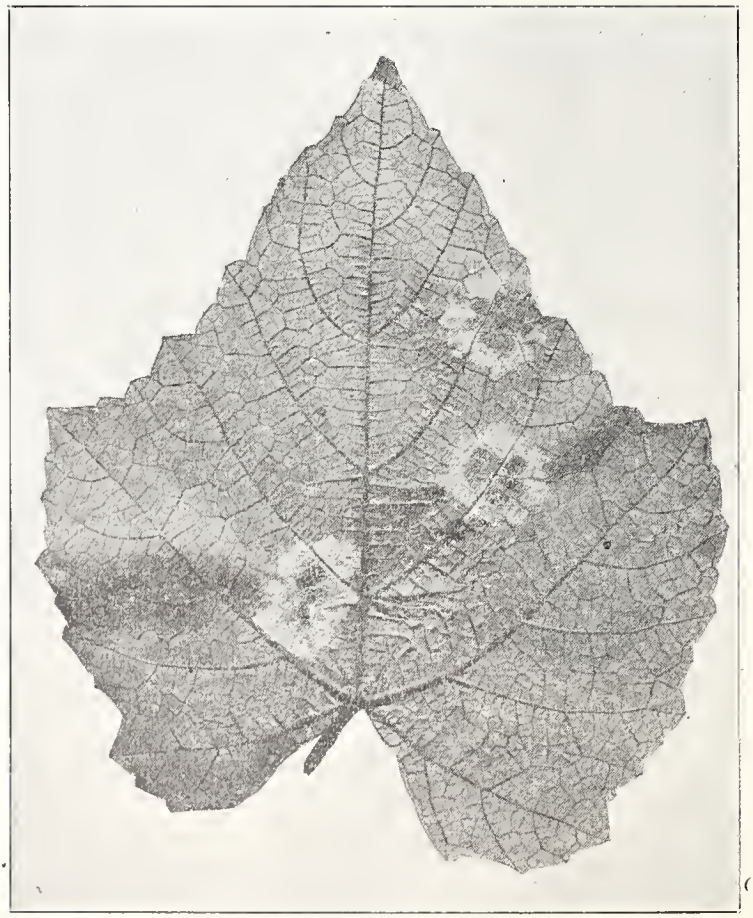

Fig. 7. Downy Mildew

change in the leaf tissue, all depending on the age of the leaf, the susceptibility of the variety, and the weather conditions. It is well known that varieties derived from European stock are more affected by downy mildew than those of American origin. Moreover, the mildew thrives best in warm weather and with plenty of moisture, so that it is likely to be discouraged by cool weather and dry conditions. This moisture relation explains why downy mildew is worst in the lower part of the vine, or in shaded locations, or in a weedy vineyard, or where the vines are bushy and crowded.

Damages Caused and Control

While the downy mildew is largely a leaf trouble, it may also occur on the young canes, tendrils, and the fruit cluster. In this last it may cause shelling because of injury to the stalk and pedicels, or it may cause a rot of the fruit.

An open, well spaced, clean, airy vineyard is less liable to mildew than a crowded, weedy, shaded one. If attention to these points does not keep this mildew down to a negligible amount, spraying may be necessary. For this purpose Bordeaux mixture has proved superior to other sprays, the copper in it being extremely deadly to the mildew fungus. The spray schedule given on page 26 will give satisfactory control of this disease.

DEAD-ARM

(*Cryptosporella viticola* (Reddick) Shear)

This trouble occurs in scattered fashion in various parts of Pennsylvania, but is of noticeable importance only in the northern grape district. Even there it must be considered a minor disease, affecting only a very small percentage of vines in any vineyard. In the last eight years it has shown little indication of becoming an important pest though in some years a noticeable increase has occurred. It should not be lightly regarded, however, for the nature of the disease is such as to render it capable of considerable damage.

Attacks Entire Vine

The fungus which is concerned in dead-arm affects the whole of the vine above ground, but appears to be unable to live below the surface, since a plant that is killed to the ground may still put out healthy shoots from the root stock. The causal fungus grows in the wood of the canes and stock, and the general vigor of the affected part is so reduced that a pronounced dwarfing occurs. (See Fig. 8) The cane growth is short and thin, and the leaves are small, closely set, yellowish in color, and curled down at the edges. The leaves

Fig. 8. Dead Arm

sunburn readily, and the affected portions of the vine may die in winter. It is common to see dead-arm on one part of a vine while the other portion is still normal; this feature distinguishes the disease from various root troubles, for where the root is affected the whole top is uniformly sickly.

The dead-arm fungus fruits on the canes and stock in a rather inconspicuous manned and spread to other vines takes place from spores thus produced. The fungus also causes small lesions on the green shoots, leaf, veins and other green portions but the chief injury comes from cane or stock infection.

Remove and Burn Diseased Vines

The careful removal and burning of diseased vines or portions of vines is the most important element in control. If this cutting out process affects the stock tissue, the cut should go well below any indication of dry rot in the wood. In case the whole vine shows symptoms it may be cut back to the ground with the expectation that a healthy renewal will take place from the root.

Spraying with Bordeaux mixture is regarded as useful in preventing spread, but unless the disease becomes troublesome spraying for this purpose alone may not be necessary.

OTHER GRAPE DISEASES

A few other grape diseases of less general importance are here mentioned.

Anthracnose (due to *Gloeosporium ampelophagum* Sacc.) is another fungus trouble causing sunken spots on the canes, and a fruit rot which goes under the name of "bird's-eye-rot" because the rot spot on the berries has a grey center with brown or dark border.

Crown Gall (*Bacterium tumefaciens,* E. F. Smith and Townsend) The American varieties are less susceptible to crown gall than European types. In addition to the familiar root galls which occur below ground and which are similar to those found on apple, raspberry, etc., the grape may have a development of gall tissue on the lower portion of the stock.

White rot due to *Coniothyrium diplodiella* (Speg.) Sacc., and *Ripe rot* caused by *Glomerella cingulata* (Stoneman) Sp. & Von S. are occasionally met with on the fruit. The latter fungus is identical with that causing the bitter rot of apple. The rot spot produced is usually marked with concentric rings.

Wet feet is common in water-logged soils where the unnatural soil conditions bring about death of the absorbing root hairs and rootlets. The foliage becomes yellow and sickly and sunburns readily.

IMPROVED SPRAY BOOMS

Several types of spray booms have been devised for applying spray materials to grapes, and these have been given repeated tests in vineyards in Pennsylvania. Two types proving most satisfactory are the U-Boom attachment and the Beuzenburg type of the Geneva spray attachment.

A modification of the U-Boom type of vineyard spray attachment has been recently designed by agricultural workers in Ohio. This outfit embraces many excellent improvements. Specifications together with Sketch and Figures have kindly been furnished us by G. A. Runner of the U. S. Bureau of Entomology. The details of construction are given in Figures 9 and 10 along with a list of material, and Fig. 11 shows the outfit in operation. The attachment is constructed of ¾″ pipe and consists of two units or booms. The first of these sprays the side of the grape row facing the tank and consists of a boom thirty inches long supporting four angle nozzles

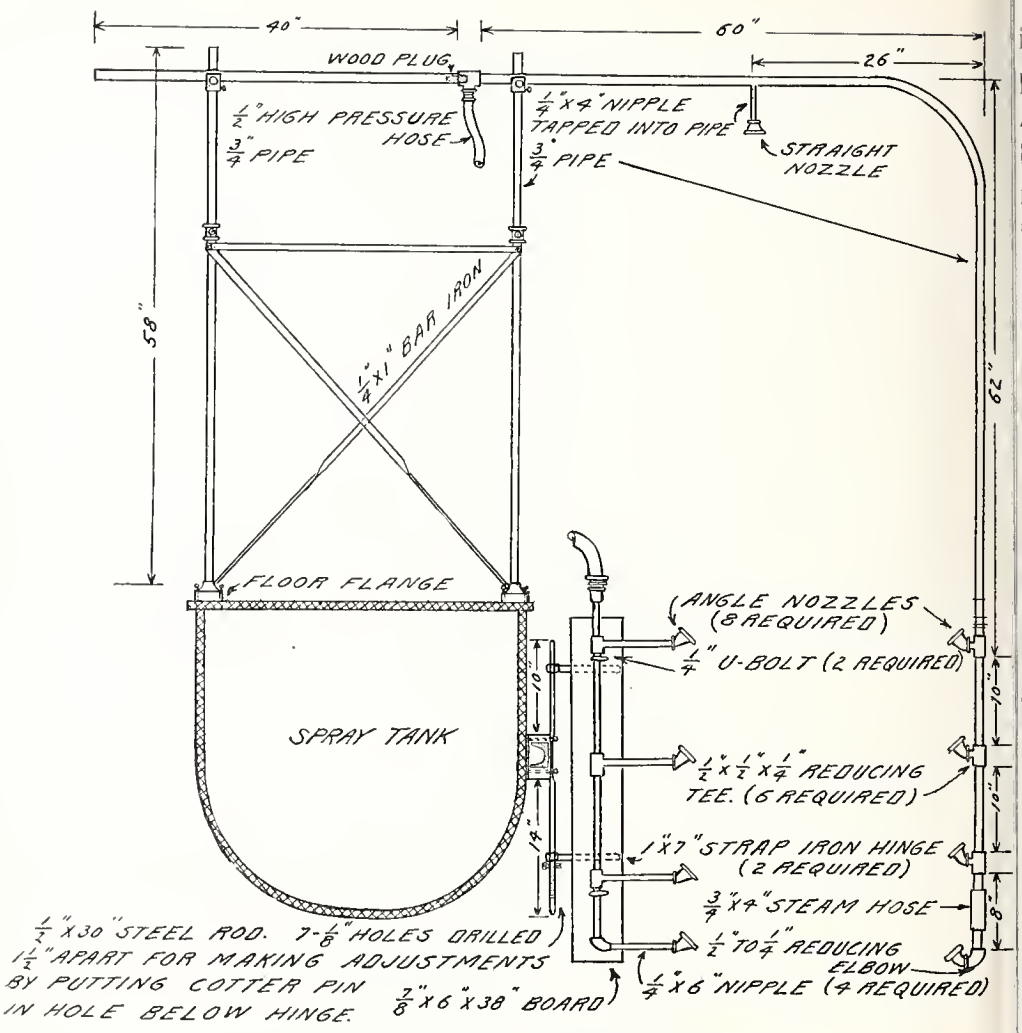

Fig. 9. Details of Modified U-Boom

which are spaced about ten inches apart and are directed toward the row and upward, at an angle of about forty-five degrees. It is held by a wooden support attached by strap hinges to an iron rod supported from a wooden brace bolted to the side of the spray tank. The lower hinge is held in place on the iron rod by a cotter pin and a series of holes drilled below, provide for the vertical adjustment of the boom by changing the position of the pin. A screen door spring attached from the tank to the front surface of the wooden support allows the boom to swing slightly backward when brushing against vines.

The unit for spraying the outer side of the grape row is made of a piece of ¾" pipe, 160 inches long, bent at right angles, so as to form a horizontal 100 inches long and a vertical 60 inches in length. A boom bearing four nozzles and similar to the first unit described is attached to the lower end of the vertical. The lower nozzle of this set

is attached to the pipe by a four inch length of steam hose which prevents its being broken or twisted off when it strikes the ground. A single straight nozzle is attached to the horizontal about 26 inches back from the bend in the pipe and directed downward over the middle of the grape row for spraying the upper surface of the foliage. The unit is held in position across the top of the spray tank by an adjustable boom support made of ¾" pipe and iron braces. (See diagram for details of the construction). A lever leading from the

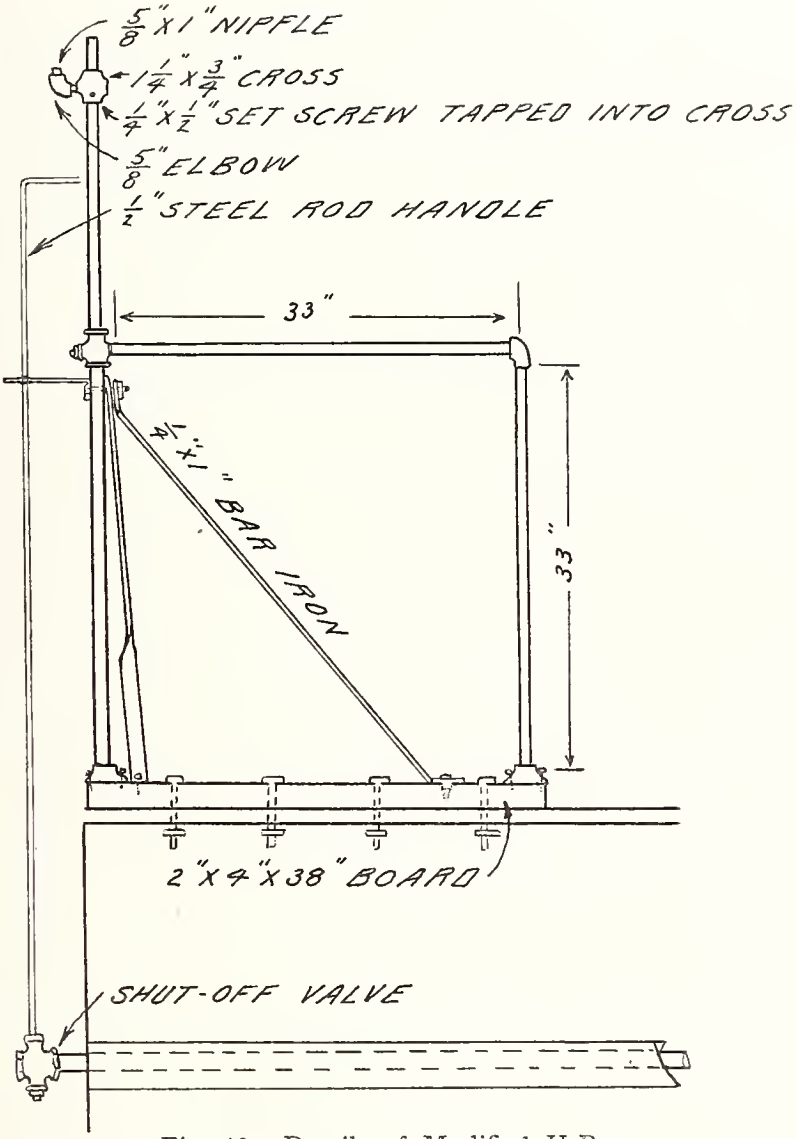

Fig. 10. Details of Modified U-Boom

shut-off valve of the tank to the boom support permits the operator to regulate the flow of spray material from his position, on top of the tank, and the spray liquid is carried into each of the two units separately by leads of hose from the tank. A pressure of 200 to 250 pounds

is necessary for the successful operation of this type of vineyard attachment. With machines producing over 300 lbs. pressure both sides of an additional row of grapes may be sprayed by adding similar booms to the other side of the tank.

Fig. 11. Modified U-Boom in Operation

Bill of Material for Vineyard Spray Attachment

1 ¾″ x 22″ nipple
1 ¾″ x 4″ nipple
1 ¾″ x 10′-4″ pipe
4 ½″ x 8½″ nipples
4 ½″ x 3½″ nipples
4 ¼″ x 1″ nipples
1 ¼″ x 2½″ nipples
1 ¼″ x 3½″ nipples
1 ¼″ x 4½″ nipples
1 ¼″ x 5½″ nipples
2 ¾″ x 5′ pipes
2 ½″ x 4″ nipples
1 ¼″ x 4″ nipple
2 ½″ x 9″ nipples
3 ¾″ pipe caps
2 ½″ street ells
4 1″ x 1″ x ½″ x ½″ crosses
1 ¾″ x ¾″ x ½″ tee
1 ¾″ brass lever valve
2 ½″ H. P. Hose connections
1 ¾″ x ½″ x ¼″ tee
4 ½″ x ½″ x ¼″ tee
1 ½″ x ½″ x ½″ tee
3 ½″ x ¼″ ells
2 ¾″ floor flanges
2 ⅜″ x 1½″ x 4′ bar iron
2 ⅜″ x 1½″ x 4′ angle braces
1¾″ x 3′ round rod
1 screen door spring
2 8″ single hinges (opening to fit ¾″ rod)
8 angle disc nozzles
1 straight disc nozzle
1 ¾″ x 4″ steam hose
Bolts and screws to fit respective places.

The Beuzenburg Boom. The modified Beuzenburg type of the Geneva attachment, as illustrated in Fig. 12, is devised to spray inner sides of two rows. It consists of two booms, each composed of three hose lines, which connect with the main feed line from the spray tank by means of a three-way hose connection. Nozzles are attached to the free end of each hose (line) by a "street ell" and turned to direct

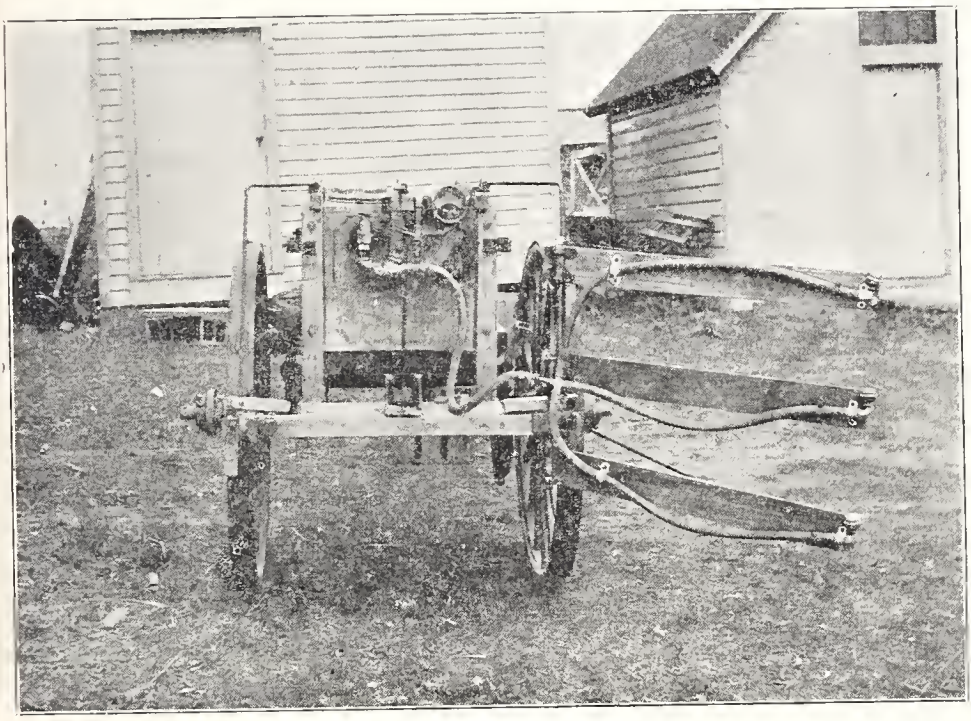

Fig. 12. The Beuzenburg Boom

the spray upward. Each hose line is supported by a wooden slat which is hinged to an iron upright supported on the rear frame of the sprayer. These slats are prolonged beyond and above the nozzles to prevent their entangling the grape vines, and are held in place against the iron uprights by means of wooden triangles and door springs, which allow their being pressed away when a protruding grape shoot is encountered. This attachment places the nozzles well into the interior of the vines, thus insuring a thorough cover of spray to the under surfaces of the leaves. It is particularly well adapted for use on two-wheeled traction and small power outfits, and requires only one man to do the spraying.

Bill of Material for the Beuzenburg Boom

2 pieces $\frac{1}{2}$" high pressure hose 33" long
4 pieces $\frac{1}{2}$" high pressure hose 40" long
2 pieces $\frac{1}{2}$" high pressure hose 30" long
Complete hose connections for same.
2 reducers $\frac{3}{4}$" x $\frac{1}{2}$"
1 4-way hose connection
1 3-way hose connection
3 reducers $\frac{1}{2}$" x $\frac{3}{8}$"
2 cut offs
6 $\frac{3}{8}$" street ells
6 $\frac{1}{4}$" short nipples
10 hose clamps
10 pipe clamps
2 $\frac{1}{4}$" iron arms about 3$\frac{1}{2}$' long
2 bent iron stops
4 brackets
6 screen door springs
6 oak slats $\frac{1}{2}$" x 4" x 36"
4 wooden triangles 10" x 2$\frac{1}{2}$" x $\frac{3}{4}$"
Rivets, bolts and washers

GRAPE SPRAY SCHEDULE FOR ERIE COUNTY

The following sprays have been followed out for several years in the grape belt of Erie County. Most successful growers make at least two spray applications per year.

1 Spray immediately after fruit sets with a 4-4-50 Bordeaux mixture to each 50 gallons of which is added 1½ pounds of dry arsenate of lead, and 1½ pounds of commercial resin fish oil soap. One quart of "Sunoco" spray oil may be used in place of the resin fish oil soap. These materials serve as spreaders. This spray is used to control grape berry moth, root worm, and mildews.

2. When the berries begin to touch in the clusters or about two weeks after Spray No 1, the same mixture should be applied with the addition of ⅜ pints of nicotine sulfate containing 40 per cent nicotine, found on the market under various trade names such as "Black Leaf 40", to each 50 gallons of spray solution. The "Black Leaf 40" is for the control of the grape leaf hopper. The poison is largely added for the control of the grape berry moth and the Bordeaux is for the control of mildews.

3. For rose chafer. In districts where the vineyards are located near sandy waste land, the rose chafers may be a serious menace to grape production. A spray composed of 4 pounds of dry arsenate of lead, 2 gallons of molasses, and 100 gallons of water should be applied to the vines as soon as the first beetles appear. This usually occurs when the Concord grapes begin to burst in blossom, but may vary with the season and the location of the vineyard. The use of the rose chafer spray will depend entirely upon the location of the vineyard and the presence of the insect.

Spray No. 2 is most important and is faithfully applied by all vineyardists who produce high-grade table grapes. In certain seasons spray No. 1 is omitted. However, this is a risky practice because it leaves the grapes unprotected during the development of the first brood of the grape berry moth and during the feeding period of the early emerging root worm beetles.

GRAPE SPRAY SCHEDULE FOR PENNSYLVANIA EXCLUSIVE OF ERIE COUNTY

The following sprays are of importance in the production of grapes in the districts outside of Erie County. The exact time indicated must be followed if control of insects and diseases are to be satisfactorily obtained.

1. For black rot and the rose chafer, spray when the new growth is 12 to 15 inches long. Use 4-4-50 Bordeaux mixture, to each 50 gal-

lons of which is added 1½ pounds of powdered arsenate of lead, 1½ pounds commercial resin-fish-oil soap, or from one-half to one gallon of home prepared resin-fish-oil soap, to each 50 gallons.

2. For black rot, the adults of the grape root worm and rose chafer and other leaf eating insects, spray immediately after the blossoms fall, using the same materials as in No. 1.

3. Two weeks after No. 2 (just as the berries begin to touch in the cluster) make a very thorough application of same material as No. 1. This is a very important spray for the control of black rot and the grape berry moth.

4. Ten days to two weeks after No. 3, repeat using same formula as No. 3.

Should the grape leaf hopper be troublesome, nicotine sulfate containing 40 per cent nicotine ("Black Leaf 40") should be added to spray No. 3 or to spray No. 2 if the insects are present in large numbers. Use the "Black Leaf 40" at the rate of ⅜ of a quart to 50 gallons of spray. Apply with a nozzle throwing a driving spray and be sure to hit the under sides of the leaves. With power spray rigs arrange a "U-Boom" as directed on page 21. A pressure of 250 pounds should be maintained with a "U-Boom".

Any Bordeaux stains which may be on the grapes at ripening time may be removed by dipping the clusters in a solution of half and half vinegar and water and then washing the clusters in clear water.

PENNSYLVANIA DEPARTMENT OF AGRICULTURE

Organization and Services

FRANK P. WILLITS, *Secretary*.....JOHN M. McKEE, *Deputy Secretary*

This Department is essentially a service agency created by legislative enactment to deal with administrative, regulatory, investigational, and educational problems which can best be solved through public rather than individual action. The organization provides for coordination and cooperation with the Pennsylvania State College and the U. S. Department of Agriculture. The Department operates through the following bureaus:

ANIMAL INDUSTRY: T. E. MUNCE, *Director and State Veterinarian.*

Prevents and Eradicates transmissible diseases of animals and poultry, including tuberculosis of animals in cooperation with Federal Government.
Demonstrates to Veterinarians control methods for transmissible animal diseases:
Supervises vaccination for and prevention of hog cholera, anthrax, black leg and hemorrhagic septicemia;
Protects public from unwholesome meats through ante and post mortem examinations of animals at slaughtering establishments:
Inspects, licenses and furnishes information as to breeding, soundness and conformation of stallions and jacks standing for public service:
Enforces law requiring licensing of dogs and providing for protection of livestock and people from attacks of uncontrolled dogs;
Maintains laboratory for diagnostic research and experimental projects.

PLANT INDUSTRY: C. H. HADLEY, *Director.*

Tests agricultural seeds for purity and germination, and enforces State Seed Law;
Inspects orchards, parks, farms, and plant imports for injurious insects and plant diseases;
Inspects and licenses Pennsylvania nurseries, and licenses all dealers in nursery stock:
Enforces laws governing apicultural practices, disease control and housing;
Places and enforces quarantines and carries on eradication campaigns against insect pests and plant diseases;
Inspects and certifies potatoes for seed purposes;
Makes investigations for the control of injurious insects and plant diseases including field tests of insecticides, fungicides and weed killers;
Maintains collection of insects, plant diseases, plants, and seeds, and identifies specimens.

FOODS AND CHEMISTRY: JAMES W. KELLOGG, *Director—Chief chemist.*

Accomplishes its purpose of protecting Pennsylvania homes against harmful foodstuffs by sampling, analyzing, and bringing prosecution under the laws relating to foods and non-alcoholic drinks, including milk, cream, butter, ice-cream, eggs, sausage, fresh meats, soft drinks, fruit syrups, vinegar and kindred food products;
Regulates and issues licenses for the manufacture and sale of oleomargarine;
Licenses and regulates egg-opening plants and cold storage warehouses, maintaining regular inspection and enforcing twelve-month storage limit;
Inspects milk plants and creameries and regulates weighing, testing, buying, and selling of milk and cream on a butterfat basis;
Protects honest manufacturers, importers, selling agents and ultimate users of feeding stuffs, fertilizers, lime products, linseed oil, paint, putty, turpentine insecticides and fungicides, by means of annual registrations followed by inspections, analyses, prosecutions and the publication of the analyses of these products;
Analyses special samples for residents of the State at the rate of $1.00 a sample for feeding stuffs, lime products and linseed oils.

MARKETS: P. R. TAYLOR, *Director.*

Investigates and assists in the marketing of farm products; at present chiefly grain and hay, fruits and vegetables, poultry and eggs, and tobacco;
Compiles and distributes daily market information as to supplies, shipments and prices;
Advises growers on transportation of agricultural products;
Assists cooperative associations and public markets;
Establishes standard grades of farm products and maintains inspection.

STATISTICS: L. H. WIBLE, *Director.*

Assembles and disseminates essential statistics and facts pertaining to the agriculture of the State, from monthly reports rendered by hundreds of volunteer crop correspondents, information which assists the producer in his sales and interests all industries which deal with agricultural products;
Cooperates with U. S. Bureau of Agricultural Economics in joint crop and livestock reporting and publishes annual and monthly summaries of the data;
Compiles dates of county and local fairs and assembles data pertaining to their success and results during each year.